

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

Amendments to the Claims:

Pursuant to this Amendment, please cancel claims 2, 3, 6, 7, 48, 49, 59, 74, 75, and 94-165 without prejudice or disclaimer, and please amend claims 1, 5, 9, 13, 14, 15, 16, 21, 32, 33, 34, 37, 38, 39, 41, 44, 47, 50, 53, 56, 57, 58, 60, 61, 62, 63, 64, 66, 69, 71, 76, 77, 78, 79, 80, 83, 84, 89, 90 and 91 as follows. This listing of claims will replace all prior versions of the claims in the application:

Listing of Claims:

1. (currently amended) A photovoltaic device, comprising:
a first electrode layer;
a second electrode layer; and
a first photoactive layer disposed between the first and second electrode layers, wherein the photoactive layer is disposed in at least partial electrical contact with the first electrode along a first plane, and in at least partial electrical contact with the second electrode along a second plane, and wherein the photoactive layer comprises material that exhibits a type II band offset energy profile, and comprises a first population of nanostructures comprising nanorods which are not grown from the first or second electrode layer and each having at least one elongated section oriented predominantly normal to at least the first plane.

2-3. Cancelled.

4. (original) The photovoltaic device of claim 1, wherein the nanostructures comprise at least a portion that is comprised of a semiconductor selected from Group II-VI, Group III-V or Group IV semiconductors or alloys thereof.

5. (currently amended) The photovoltaic device of claim 1, wherein the population of nanostructures comprises nanocrystal nanorods that comprise one or more

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

of: CdSe, CdTe, InP, InAs, CdS, ZnS, ZnSe, ZnTe, HgTe, GaN, GaP, GaAs, GaSb, InSb, Si, Ge, AlAs, AlSb, PbSe, PbS, or PbTe.

6-7. Cancelled.

8. (original) The photovoltaic device of claim 1, wherein the nanostructures comprise: a single-crystal nanostructure, a double-crystal nanostructure, a polycrystalline nanostructure, or an amorphous nanostructure.

9. (currently amended) The photovoltaic device of claim 1, wherein the population of ~~nanostructures comprises nanocrystal that~~ nanorods comprise a core of a first semiconductor material and a shell of a second semiconductor material, which second semiconductor material is different from the first semiconductor material.

10. (original) The photovoltaic device of claim 9, wherein the first and second semiconductor materials comprise a type-II band offset profile.

11. (original) The photovoltaic device of claim 10, wherein the core comprises CdSe and the shell comprises CdTe.

12. (original) The photovoltaic device of claim 10, wherein the core comprises InP and the shell comprises GaAs.

13. (currently amended) The photovoltaic device of claim 1, wherein the photoactive layer comprises ~~nanocrystal-nanorods~~ disposed in a conductive polymer matrix, and wherein the ~~nanocrystal-nanorods~~ are coupled to the polymer matrix.

14. (currently amended) The photovoltaic device of claim 13, wherein the ~~nanocrystals-nanorods~~ are coupled to the polymer matrix via a covalent chemical linkage.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

15. (currently amended) The photovoltaic device of claim 14, wherein the chemical linkage comprises a ligand coupled at a first position to an outer surface of the nanocrystal-nanorod and at a second position to the polymer matrix.

16. (currently amended) The photovoltaic device of claim 13, wherein the nanocrystals-nanorods are electrically coupled to the polymer matrix.

17. (original) The photovoltaic device of claim 1, wherein the population of nanostructures is predominantly positioned closer to the first electrode than to the second electrode.

18. (original) The photovoltaic device of claim 1, further comprising a hole or electron blocking layer disposed between the photoactive layer and the first or second electrode.

19. (original) The photovoltaic device of claim 1, further comprising a hole blocking layer disposed between the photoactive layer and the first electrode and an electron blocking layer disposed between the photoactive layer and the second electrode.

20. (original) The photovoltaic device of claim 1, wherein at least one of the first and second electrodes are flexible.

21. (currently amended) The photovoltaic device of claim 20, wherein the first and second electrodes and the photoactive layers layer are flexible.

22. (original) The photovoltaic device of claim 1, wherein at least one of the first and second electrodes comprises a transparent conductive layer.

23. (original) The photovoltaic device of claim 1, wherein the device comprises a transparent support layer at least partially covering the first or second

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

electrode, or at least partially covering the photoactive layer, or at least partially covering a combination thereof.

24. (original) The photovoltaic device of claim 1, wherein at least one of the electrodes comprises aluminum.

25. (original) The photovoltaic device of claim 1, wherein the photoactive layer is hermetically sealed.

26. (original) The photovoltaic device of claim 25, the device comprising at least one sealing layer in addition to the first and second electrodes.

27. (original) The photovoltaic device of claim 26, wherein the device comprises at least first and second sealing layers, the photoactive layer and first and second electrodes being sandwiched between the first and second sealing layers.

28. (original) The photovoltaic device of claim 1, wherein the overall device comprises a non-planar architecture.

29. (original) The photovoltaic device of claim 1, wherein the device comprises a convex architecture.

30. (original) The photovoltaic device of claim 1, wherein the first electrode layer, the photoactive layer and the second electrode layer are oriented in a coiled architecture.

31. (original) The photovoltaic device of claim 1, wherein the first electrode layer, the photoactive layer and the second electrode layer are oriented in a reciprocating stacked architecture.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

32. (currently amended) The photovoltaic device of claim 1, wherein the population of nanostructures in the photoactive layer comprises at least a second two different nanocrystal subpopulations, each the second nanocrystal subpopulation having a different absorption spectrum than the nanorods.

33. (currently amended) The photovoltaic device of claim 32, wherein the nanorods and the second different nanocrystal subpopulation comprise different compositions.

34. (currently amended) The photovoltaic device of claim 32, wherein the nanorods and the second different nanocrystal subpopulations subpopulation comprise nanocrystals having different size distributions.

35. (original) The photovoltaic device of claim 1, wherein the nanostructures in the photoactive layer collectively comprise at least two inorganic materials.

36. (original) The photovoltaic device of claim 1, wherein the nanostructures in the photoactive layer collectively comprise at least two inorganic materials, wherein the nanostructures comprise a core of a first inorganic material and a shell of a second inorganic material.

37. (currently amended) The photovoltaic device of claim 1, wherein the photoactive layer comprises at least two types of nanocrystals nanostructures.

38. (currently amended) The photovoltaic device of claim 1, wherein the photoactive layer comprises fused, partially fused, and/or sintered nanocrystals nanorods.

39. (currently amended) The photovoltaic device of claim-436, wherein the cores of at least two adjacent nanostructures in the photoactive layer are in at least

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

partial electrical contact, and wherein the shells of the at least two adjacent nanostructures, or at least two additional nanostructures, are in at least partial direct electrical contact.

40. (original) The photovoltaic device of claim 1, wherein the photoactive layer comprises at least two active sublayers.

41. (currently amended) The photovoltaic device of claim 1, wherein the photoactive layer comprises at least two active sublayers, wherein each of the active sublayers comprises a plurality of ~~nano~~crystals nanorods of at least one nanocrystal type.

42. (original) The photovoltaic device of claim 1, wherein the photoactive layer comprises at least two sublayers, wherein at least one of the at least two sublayers comprises an n-type sublayer and at least one of the two sublayers comprises a p-type sublayer.

43. (original) The photovoltaic device of claim 1, wherein the photoactive layer comprises at least two sublayers, wherein at least one of the at least two sublayers comprises an n-type sublayer and at least one of the two sublayers comprises a p-type sublayer, wherein the photoactive layer comprises a junction between the p-type sublayer and the n-type sublayer.

44. (currently amended) The photovoltaic device of claim 1, wherein the photoactive layer comprises at least one sublayer comprising a blend of p and n ~~nano~~crystals-nanorods.

45. (original) The photovoltaic device of claim 1, wherein the device comprises at least a second photoactive layer.

46. (original) The photovoltaic device of claim 1, further comprising:

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

a third electrode layer;

a fourth electrode layer; and

a second photoactive layer disposed between the third and fourth electrode layers, wherein the second photoactive layer is disposed in at least partial electrical contact with the third electrode along a third plane, and in at least partial electrical contact with the fourth electrode along a fourth plane, and wherein the second photoactive layer exhibits a type II band offset energy profile, and comprises a second population of nanostructures each having at least one elongated section oriented predominantly normal to at least the third plane, and having a different absorption spectrum from the first population of nanostructures, wherein the third electrode layer, fourth electrode layer and second photoactive layer are attached to, but electrically insulated from the first electrode layer, second electrode layer and first photoactive layer.

47. (currently amended) A photovoltaic device, comprising:

a first electrode layer;

a second electrode layer; and,

a first photoactive layer disposed between the first and second electrode layers, wherein the photoactive layer is disposed in at least partial electrical contact with the first electrode along a first plane and in at least partial electrical contact with the second electrode along a second plane, wherein the photoactive layer comprises a first inorganic material and a second inorganic material different from the first inorganic material, which first and second inorganic materials exhibit a type II band offset energy profile, and wherein the photoactive layer comprises a first population of nanostructures comprising nanotetrapods comprising the first inorganic material which are not grown from the first or second electrode layer and a second population of nanostructures comprising the second inorganic material, which nanostructures comprise the first inorganic material, the second inorganic material, or a combination thereof.

48-49. Cancelled.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

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50. (currently amended) The photovoltaic device of claim 47, wherein the first and second population of nanostructures comprise: a single-crystal nanostructure, a double-crystal nanostructure, a polycrystalline nanostructure, or an amorphous nanostructure.

51. (original) The photovoltaic device of claim 47, wherein the first inorganic material is a semiconductor and wherein the second inorganic material is a semiconductor.

52. (original) The photovoltaic device of claim 47, wherein the first inorganic material comprises a first semiconductor selected from the group consisting of: a Group II-VI semiconductor, a Group III-V semiconductor, a Group IV semiconductor, and an alloy thereof, and wherein the second inorganic material comprises a second semiconductor, different from the first semiconductor, selected from the group consisting of: a Group II-VI semiconductor, a Group III-V semiconductor, a Group IV semiconductor, and an alloy thereof.

53. (currently amended) The photovoltaic device of claim 47, wherein the first population of nanostuctures comprises nanocrystals that nanotetrapods comprise a core of the first inorganic material and a shell of the second inorganic material.

54. (original) The photovoltaic device of claim 53, wherein the core comprises CdSe and the shell comprises CdTe.

55. (original) The photovoltaic device of claim 53, wherein the core comprises InP and the shell comprises GaAs.

56. (currently amended) The photovoltaic device of claim 53, wherein the nanocrystals-nanotetrapods are fused, partially fused, and/or sintered.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

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57. (currently amended) The photovoltaic device of claim 53, wherein the cores of at least two adjacent nanoerystals-nanotrapods are in at least partial direct electrical contact and wherein the shells of at least two adjacent nanoerystals-nanotrapods are in at least partial direct electrical contact.

58. (currently amended) The photovoltaic device of claim 53, wherein the cores of one or more nanoerystals-nanotrapods are in at least partial direct electrical contact with the first electrode layer or the second electrode layer.

59. Cancelled.

60. (currently amended) The photovoltaic device of claim 4759, wherein the first inorganic material comprises CdSe and the second inorganic material comprises CdTe, the first inorganic material comprises CdS and the second inorganic material comprises CdTe, or the first inorganic material comprises CdS and the second inorganic material comprises ZnSe.

61. (currently amended) The photovoltaic device of claim 4759, wherein adjacent nanoerystals-nanostructures from the first and second population are in at least partial direct electrical contact with each other.

62. (currently amended) The photovoltaic device of claim 4759, wherein the nanoerystals-nanotrapods of the first population and the nanostructures-nanoerystals of the second population are intermixed in the photoactive layer.

63. (currently amended) The photovoltaic device of claim 4759, wherein the photoactive layer comprises at least a first sublayer and a second sublayer, wherein the first sublayer comprises the first population of nanoerystals-nanotrapods and the second sublayer comprises the second population of nanostructures-nanoerystals.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

BEST AVAILABLE COPY

64. (currently amended) The photovoltaic device of claim 47, wherein the ~~nano~~crystals-nanostructures of the first and/or second populations are fused, partially fused, and/or sintered.

65. (original) The photovoltaic device of claim 47, wherein the photoactive layer comprises at least two active sublayers.

66. (currently amended) The photovoltaic device of claim 47, wherein the photoactive layer comprises at least two active sublayers, wherein each of the active sublayers comprises a plurality of ~~nano~~crystals-nanostructures of at least one nanocrystal type.

67. (original) The photovoltaic device of claim 47, wherein the photoactive layer comprises at least two sublayers, wherein at least one of the at least two sublayers comprises an n-type sublayer and at least one of the two sublayers comprises a p-type sublayer.

68. (original) The photovoltaic device of claim 47, wherein the photoactive layer comprises at least two sublayers, wherein at least one of the at least two sublayers comprises an n-type sublayer and at least one of the two sublayers comprises a p-type sublayer, wherein the photoactive layer comprises a junction between the p-type sublayer and the n-type sublayer.

69. (currently amended) The photovoltaic device of claim 47, wherein the photoactive layer comprises at least one sublayer comprising a blend of p and n ~~nano~~crystals-nanotrapods.

70. (original) The photovoltaic device of claim 47, wherein the photoactive layer further comprises a conductive polymer.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

BEST AVAILABLE COPY

71. (currently amended) The photovoltaic device of claim 47, wherein the photoactive layer is substantially free of conductive polymer.

72. (original) The photovoltaic device of claim 47, wherein the photoactive layer further comprises a nonconductive polymer.

73. (original) The photovoltaic device of claim 47, wherein the nanostructures of the first population each has at least one elongated section oriented predominantly normal to at least the first plane.

74-75. Cancelled.

76. (currently amended) The photovoltaic device of claim 47, further comprising a hole or electron blocking layer disposed between the photoactive layer and the first or second electrode layer.

77. (currently amended) The photovoltaic device of claim 47, further comprising a hole blocking layer disposed between the photoactive layer and the first electrode layer and an electron blocking layer disposed between the photoactive layer and the second electrode layer.

78. (currently amended) The photovoltaic device of claim 47, wherein at least one of the first and second electrodes layers are flexible.

79. (currently amended) The photovoltaic device of claim 78, wherein the first and second electrodes and the photoactive layer are flexible.

80. (currently amended) The photovoltaic device of claim 47, wherein at least one of the first and second electrodes layers comprises a transparent conductive layer.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

BEST AVAILABLE COPY

81. (original) The photovoltaic device of claim 47, wherein at least one of the electrodes comprises aluminum.

82. (original) The photovoltaic device of claim 47, wherein the photoactive layer is hermetically sealed.

83. (currently amended) The photovoltaic device of claim 82, the device comprising at least one sealing layer in addition to the first and second electrodes layers.

84. (currently amended) The photovoltaic device of claim 83, wherein the device comprises at least first and second sealing layers, the photoactive layer and first and second electrodes layers being sandwiched between the first and second sealing layers.

85. (original) The photovoltaic device of claim 47, wherein the overall device comprises a non-planar architecture.

86. (original) The photovoltaic device of claim 47, wherein the device comprises a convex architecture.

87. (original) The photovoltaic device of claim 47, wherein the first electrode layer, the photoactive layer and the second electrode layer are oriented in a coiled architecture.

88. (original) The photovoltaic device of claim 47, wherein the first electrode layer, the photoactive layer and the second electrode layer are oriented in a reciprocating stacked architecture.

Appl. 10/656,802
Amnd dated September 21, 2004
Reply to Office Action of July 8, 2004

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89. (currently amended) The photovoltaic device of claim 47, wherein the first and second population of nanostructures ~~comprises at least two different nanocrystal subpopulations, each nanocrystal subpopulation having a~~ have different absorption spectrum.

90. (currently amended) The photovoltaic device of claim 89, wherein the first and second different nanocrystal subpopulations ~~populations of nanostructures~~ comprise different compositions.

91. (currently amended) The photovoltaic device of claim 89, wherein the ~~different nanocrystal subpopulations comprise nanocrystals having first and second populations of nanostructures have~~ different size distributions.

92. (original) The photovoltaic device of claim 47, wherein the device comprises at least a second photoactive layer.

93. (original) The photovoltaic device of claim 47, further comprising:
a third electrode layer;
a fourth electrode layer; and,
a second photoactive layer disposed between the third and fourth electrode layers, wherein the second photoactive layer is disposed in at least partial electrical contact with the third electrode along a third plane and in at least partial electrical contact with the fourth electrode along a fourth plane, wherein the second photoactive layer comprises a second population of nanostructures having a different absorption spectrum from the first population of nanostructures, and wherein the third electrode layer, fourth electrode layer and second photoactive layer are attached to, but electrically insulated from, the first electrode layer, second electrode layer and first photoactive layer.

94-165 (cancelled).

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